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APPLICATION OF LINK ADJACENCY VALUES ON SIX LINK PLANAR MECHANISMS FOR IDENTIFICATION OF ISOMORPHISM

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ABSTRACT

In present days, researchers deal with a problem to identify the isomorphism in structural synthesis among the kinematic chains (KC). In recent times, a new method was proposed named as Link adjacency values. In this method, two new values for each link, named as first adjacency link value (FALV) and second adjacency link value (SALV). These values detect the isomorphism among the kinematic chains of a mechanism. Another two invariants, maximum first adjacency link value and maximum second adjacency link value, which are the by- product of the same method has been proposed to detect isomorphism among kinematic chains. These invariants take into account the degree of freedom, number of links, nodes and type of a joint. In this paper, this link adjacency values is applied on six link planar mechanisms i.e. sewing machine mechanism, brake drum mechanism and straight line motion mechanism. The calculations for all these mechanisms are shown in paper and isomorphic mechanisms are identified based on it.

KEYWORDS: Kinematic Chains (KC), First Adjacency Link Value (FALV) and Second Adjacency Link Value (SALV)

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Original Article

INTRODUCTION

A lot of researches have been done to identify the isomorphism of the kinematic chains for doing the analysis and structure synthesis of different mechanisms. In structure synthesis of kinematic chains, most encountered problem is to identify the isomorphism among the kinematic chains. Two chains are isomorphic, if there is one link of a chain correspondence to another link of another chain.

In the kinematic chain of a mechanism, the structural synthesis problems occur due to steps of synthesis, structural number of links and degree of freedom (d.o.f). But, all of this structure synthesis is to present the all possible arrangements of kinematic chain of mechanisms for number of links, d.o.f and nodes of a mechanism. So, designer selects the best mechanisms according to requirements. When a designer develops the kinematic chain of a mechanism, the duplication occurs. The second name of duplication in kinematic chain is isomorphism.

Isomorphism detects the similarity among the kinematic chains of a mechanism.Unidentified Isomorphism increase efforts and the chance of duplications. The isomorphism identification and analysis of mechanism kinematic chain is a time saving and correct synthesis. In this paper, structure synthesis of three mechanism namely sewing machine mechanism, brake drum mechanism and straight line motion mechanism is being done.

A large number of researches exists on isomorphism and discover the number of methods to detect the isomorphism of among kinematic chains. Study is continued for efficient and reliable method. Ashok Dargara, Ali Hasanb and R. A. Khanb [1] proposed a method based upon Link adjacency values which give correct result based

on different invariant values to detect isomorphism among the kinematic chains. First, adjacency link value (FALV) and second adjacency link value (SALV) are used to detect distinct inversions of a mechanism. Isomorphism is identified by another two invariant values, maximum first adjacency link value and maximum second adjacency link value. Jin-Kui, Chu and Wei-Qing, Cao [2] studied topological relation between the kinematic chain links topological a study those properties of a structure do not change, when homeomorphisms are applied. Adjacent matrix, link's adjacent chain table (ACT) dealt to identify isomorphism of topological links. Haider Rizvi and Ali Hasan, [3] dealt with a method based on Fuzzy similarity index which is fastest and quick among the methods. Fuzzy numbers similarity identifies the isomorphism among the kinematic chains. It is easiest numerical method. Shende, S. and Rao, A.C. [4] dealt with isomorphism which is useful for detecting the structure synthesis of kinematic chains. The main advantage of this technique is, time saving process. The summation polynomials method describes the properties of topological kinematic chain. It is capable to testing isomorphism among the planner chains i.e. simple and multiple jointed chains. Mahere, Vishesh and Nigam, S.P. [5] introduce adjacency matrix or vertex matrix, which describes the properties of a mechanical structure such as degree of freedom and number of joints. The result find out by the square matrix values will be zero or one depend upon one link connection to another link. Yadav, J.N.; Agrawal, V.P. and Pratap, C.R. [6] developed Arranged Sequences of Total Multiplicity Distance Ranks of all the Links (ASTMDRL), to identify the isomorphism with this computer based method. This invariant is based on computer aided time saving and quick response method.

METHODOLGY

This is an approach to detect the isomorphism among the kinematic chains, which eliminates duplication of solution and unnecessary efforts. Link adjacency values has wide range of applications and do not depends upon sufficient conditions. It is very helpful in engineering and physical structural problems.

- Degree of link – A numerical value of the link depends on connectivity to other link the ternary link has degree equal to three and binary link has two degree of link.
- Joint value – For a particular joint value it is define as the ratio of sum of degree of all connected links to the number of links connected at the joint. It denoted by J_v.

$$J_v = \frac{\sum degree\ of\ all\ the\ connected\ link}{number\ of\ link\ connected\ at\ the\ joint}$$

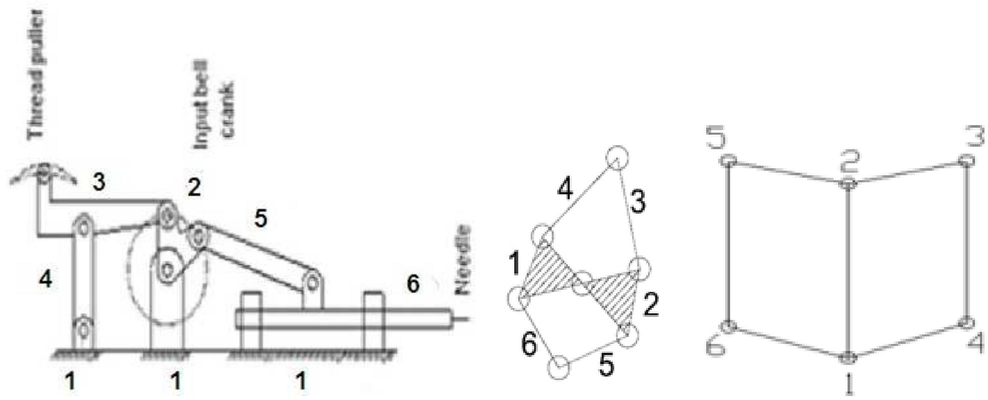
- Link value – It is define as for link value of a particular link sum of all joint values of that link. The link value for link 1 and 2 of the chain.
- New structural invariants are first adjacency link value [FALV] and second adjacency link value [SALV].

Sewing Machine

The physical and graphical representation of this mechanism is shown in Figure 1.

Joint Values: The joint values of the different joints are as follows:

J_a = (3+2) / 2 = 2.5, J_b = (3+2) / 2 = 2.5, J_c = (2+2) / 2 = 2, J_d = (3+2) / 2 = 2.5, J_e = (2+3) / 2 = 2.5, J_f = (2+2) / 2 = 2.0, J_g = (3+3) / 2 = 3.0.



(a) (b) (c)

Figure 1: (a) Feed Mechanism (b) Schematic Representation (c) Weighted Graph of Sewing Machine Source: Verma S. & Singh V.P [7]

Link Values:

$L_1 = a + b + g = 2.5 + 2.5 + 3 = 8$ $L_2 = e + d + g = 2.5 + 2.5 + 3 = 8$

$L_3 = d + c = 2.5 + 2 = 4.5$ $L_4 = b + c = 2.5 + 2 = 4.5$

$L_5 = f + e = 2 + 2.5 = 4.5$ $L_6 = a + f = 2.5 + 2 = 4.5$

First Adjacency Link Values:

$L_{1f} = L_4 + L_6 + L_2 = 17$ $L_{2f} = L_3 + L_5 + L_1 = 17$

$L_{3f} = L_4 + L_2 = 12.5$ $L_{4f} = L_3 + L_1 = 12.5$

$L_{5f} = L_2 + L_6 = 12.5$ $L_{6f} = L_5 + L_1 = 12.5$

Second Adjacency Link Values:

$L_{1s} = L_{4f} + L_{6f} + L_{2f} = 42$ $L_{2s} = L_{3f} + L_{5f} + L_{1f} = 42$

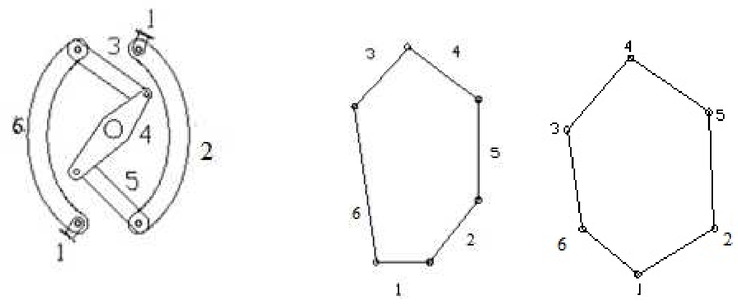
$L_{3s} = L_{4f} + L_{2f} = 29.5$ $L_{4s} = L_{3f} + L_{1f} = 29.5$

$L_{5s} = L_{2f} + L_{6f} = 29.5$ $L_{6s} = L_{5f} + L_{1f} = 29.5$

FALV max = 17 and SALV max = 42

Brake Drum Mechanism

The physical and graphical representation of this mechanism is shown in Figure 2.



(a) **(b)** **(c)**

Figure 2: (a) Physical Representation (b) Schematic Representation (c) Weighted Graph of Brake Drum Mechanism

Source: Verma S. & Singh V.P [7]

Joint Values: The joint values of the different joints are as follows:

$J_a = (2+2) / 2 = 2$, $J_b = (2+2) / 2 = 2$, $J_c = (2+2) / 2 = 2$, $J_d = (2+2) / 2 = 2$, $J_e = (2+2) / 2 = 2$, $J_f = (2+2) / 2 = 2$

Link Values:

$L_1 = a + f = 2.5 + 2.5 + 3 = 4$ $\quad L_2 = a + b = 2 + 2 = 8$

$L_3 = b + c = 2 + 2 = 4$ $\quad L_4 = c + d = 2 + 2 = 4$

$L_5 = d + e = 2 + 2 = 4$ $\quad L_6 = e + f = 2 + 2 = 4$

First Adjacency Link Values:

$L_{1f} = L_2 + L_6 = 8$ $\quad L_{2f} = L_3 + L_1 = 8$

$L_{3f} = L_2 + L_4 = 8$ $\quad L_{4f} = L_3 + L_5 = 8$

$L_{5f} = L_4 + L_6 = 8$ $\quad L_{6f} = L_1 + L_5 = 8$

Second Adjacency Link Values:

$L_{1s} = L_{2f} + L_{6f} = 16$ $\quad L_{2s} = L_{3f} + L_{1f} = 16$

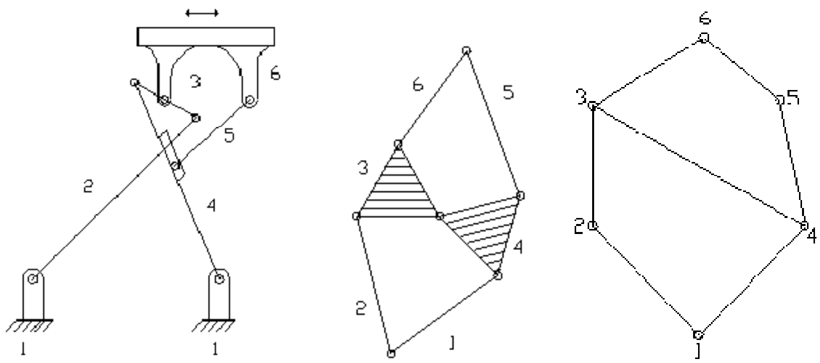
$L_{3s} = L_{2f} + L_{4f} = 16$ $\quad L_{4s} = L_{3f} + L_{5f} = 16$

$L_{5s} = L_{4f} + L_{6f} = 16$ $\quad L_{6s} = L_{1f} + L_{5f} = 16$

FALV max = 8 and SALV max = 16

Straight Line Motion Mechanism

The physical and graphical representation of this mechanism is shown in Figure 3.



(a) **(b)** **(c)**

Figure 3: (a) Physical Representation (b) Schematic Representation (c) Weighted Graph of Straight Line Motion Mechanism

Source: Verma S. & Singh V.P [7]

Joint Values: The joint values of the different joints are as follows: $J_a = (2+2) / 2 = 2$, $J_b = (3+2) / 2 = 2.5$, $J_c = (2+2) / 2 = 2$, $J_d = (2+2) / 2 = 2$, $J_e = (2+3) / 2 = 2.5$, $J_f = (3+2) / 2 = 2.5$, $J_g = (3+3) / 2 = 3$

Link Values:

$L_1 = a + f = 2 + 2.5 = 4.5$ $L_2 = a + b = 2 + 2.5 = 4.5$

$L_3 = b + c + g = 2.5 + 2.5 + 3 = 8$ $L_4 = e + f + g = 2.5 + 2.5 + 3 = 8$

$L_5 = e + d = 2.5 + 2 = 4.5$ $L_6 = a + f = 2 + 2.5 = 4.5$

First Adjacency Link Values:

$L_{1f} = L_4 + L_6 + L_2 = 12.5$ $L_{2f} = L_3 + L_5 + L_1 = 12.5$

$L_{3f} = L_4 + L_2 = 17$ $L_{4f} = L_3 + L_1 = 17$

$L_{5f} = L_2 + L_6 = 12.5$ $L_{6f} = L_5 + L_1 = 12.5$

Second Adjacency Link Values:

$L_{1s} = L_{2f} + L_{4f} = 29.5$ $L_{2s} = L_{1f} + L_{3f} = 29.5$

$L_{3s} = L_{2f} + L_{6f} + L_{4f} = 42$ $L_{4s} = L_{1f} + L_{3f} + L_{5f} = 42$

$L_{5s} = L_{6f} + L_{2f} = 29.5$ $L_{6s} = L_{3f} + L_{5f} = 29.5$

FALV max = 17 and SALV max = 42

For chain 1:

FALV max = 17 and SALV max = 42

For chain 2:

FALV max = 8 and SALV max = 16

For chain 3:

FALV max = 17 and SALV max = 42

RESULTS

As the maximum first adjacency link value and maximum second adjacency link value of sewing machine mechanism and straight line motion mechanism are identical, it is concluded that these two mechanisms are isomorphic. But, brake drum mechanism is non isomorphic with these mechanisms.

CONCLUSIONS

In this paper, isomorphism is identified and structure synthesis of mechanisms is done with the help of link adjacency values. This method is based on two invariants, which gave correct result based on visual inspection of any graph of the kinematic chain. This unique method deals with all inherent properties of mechanism. The proposed method is new concept to detect the isomorphism of complex kinematic chain of any size. Hence, it is good approach for testing isomorphism among three kinematic chains for precise results.

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